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FEE TRANSMITTAL for FY 2003

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☒ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) $0

Complete if Known	
Application Number	10/072,676
Filing Date	February 7, 2002
First Named Inventor	Michael Wendell Vice
Examiner Name	Terry D. Cunningham
Group / Art Unit	2816
Attorney Docket No.	2451-2

METHOD OF PAYMENT (check one)

☒ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None

☒ Deposit Account:

Deposit Account Number	5022-32
Deposit Account Name	Glenn C. Brown, P.C.

The Commissioner is authorized to: (*check all that apply*)

☐ Charge fee(s) indicated below
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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	750	2001	375	Utility filing fee	
1002	330	2002	165	Design filing fee	
1003	520	2003	260	Plant filing fee	
1004	750	2004	375	Reissue filing fee	
1005	160	2005	80	Provisional filling fee	

SUBTOTAL (1) ($)

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X		=	
Independent Claims		-3** =		X		=	
Multiple Dependent				X		=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	84	2201	42	Independent claims in excess of 3
1203	280	2203	140	Multiple dependent claim, if not paid
1204	84	22204	42	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($)

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.	
1053	130	1053	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	410	2252	205	Extension for reply within second month	
1253	930	2253	465	Extension for reply within third month	
1254	1,450	2254	725	Extension for reply within fourth month	
1255	1,970	2255	985	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	165
1402	320	2402	160	Filing a brief in support of an appeal	
1403	280	2403	140	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive – unavoidable	
1453	1,300	2453	650	Petition to revive – unintentional	
1501	1,300	2501	650	Utility issue fee (or reissue)	
1502	470	2502	235	Design issue fee	
1503	630	2503	315	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	750	2809	375	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810	750	2810	375	For each additional invention to be examined (37 CFR § 1.129(b))	
1801	750	2801	375	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

The PTO did not receive the following listed items(s) [handwritten initials]

Other fee (specify)

*Reduced by Basic Filing Fee Paid SUBTOTAL (3) ($)0

SUBMITTED BY			Complete (*if applicable*)		
Name (Print/Type)	Glenn C. Brown	*Registration No. Attorney/Agent)*	34,555	*Telephone*	541/312-2500
Signature	[signature]			*Date*	July 6, 2004

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Patent
2429-3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BOARD OF PATENT APPEALS AND INTERFERENCES

In re application of:	)	Examiner: Terry D. Cunningham
	)	
Michael Wendell Vice	)	Art Unit: 2816
	)	
Serial No. 10/072,676	)	
	)	
Filed: February 7, 2002	)	
	)	
Title: Series Active Filtering Power Line Conditioner	)	
	)	

Board of Patent Appeals and Interferences
Commissioner of Patents and Trademarks
Washington, D.C. 20231

REPLY BRIEF
UNDER 37 CFR §1.193(b)(1)

This reply brief is responsive to the Examiner's Answer mailed May 5, 2004.

CERTIFICATE OF MAILING UNDER 37 C.F.R. § 1.8

I hereby certify, pursuant to 37 C.F.R. § 1.8 that this paper or fee (along with any referred to as being attached or enclosed) is being deposited with the U.S. Postal Service with sufficient postage as first class mail on the date shown below in an envelope addressed to: Commissioner for Patents, Mail Stop Appeal Brief Patents, Post Office Box 1450, Alexandria, Virginia 22213-1450.

Dated: July 6, 2004

By: Cheryl J. Blackman
Cheryl J. Blackman

This Reply Brief is transmitted in triplicate.

This Reply Brief contains these items under the following headings, and in the order set forth below.

TABLE OF CONTENTS

I. REAL PARTY IN INTEREST
37 CFR §1.192(c) (1)

The real party in interest is the Applicant named in the caption of this Brief.

II. RELATED APPEALS AND INTERFERENCES
37 CFR §1.192(c) (2)

The Board's decision in the present Appeal will not directly affect, or be directly affected, or have any bearing on any other appeals or interferences known to the appellant, or to the appellant's legal representative. There is no assignee.

III. STATUS OF CLAIMS
37 CFR §1.192(c) (3)

The following statement of the status of the claims has been corrected in response to the Examiner's Answer.

Status of All the Claims:

1. Claims presented: 1-25
2. Claims withdrawn from consideration but not cancelled: NONE
3. Claims canceled: NONE
4. Claims pending: 1-25 of which:
    a. claims objected to: 3-25
    b. claims rejected: 1-2
    c. claims allowed: NONE

All the rejected claims, namely claims 1 and 2, are being appealed. The appealed claims are eligible for appeal, having been finally rejected.

IV. STATUS OF AMENDMENTS
37 CFR §1.192(c) (4)

The last Office Action mailed on 05/14/2003 contained a Final Rejection of claims 1-25.

Applicant subsequently requested a telephonic interview with the Examiner in an effort to understand and discuss the rejection, but the request was denied by the Examiner without any apparent or stated reason.

After the Appeal Brief was submitted, a telephonic interview was conducted in March 2004, during which agreement was reached concerning claim 3.

V. SUMMARY OF THE INVENTION
37 CFR §1.192(c) (5)

The power conditioner of the present invention is a linear, real time control system that acts to remove harmonic and spurious distortion and noise from an external source of AC power. The preferred embodiment of the apparatus includes a transformer and an active filter coupled in series to a power distribution network. The power distribution network includes a voltage source that induces input currents at a first end of the power distribution network. Nonlinear loads and other conditions on the power distribution network cause harmonic, spurious, and random noise components that corrupt the power signals. The active filter of the present invention uses a monochromatic reference derived from the incoming AC power voltage which is prepared by stripping off unwanted harmonics and noise and regulating amplitude to a predetermined value. A feedback control system is configured to operate in series with

a secondary winding of the transformer so as to effectively subtract voltage imperfections from the incoming AC. The control loop is compensated in such a way that it is stabilized without compromising bandwidth.

VI. ISSUES ON APPEAL
37 CFR §1.192(c) (6)

The following statement of the issues on appeal has been corrected in response to the Examiner's Answer.

A. Whether claims 1-2 are unpatentable under 35 U.S.C. §102(b). See Examiner's Final Action, page 3.

VII. GROUPING OF CLAIMS
37 CFR §1.192(c) (7)

Claims 1-2 stand rejected under 35 U.S.C. 102 over U.S. Patent No. 5,093,531 to Estes ("Estes, Jr."). The Examiner generally asserts that each element of the invention of claims 1 and 2 is disclosed by Estes, Jr. Applicant is unable to locate each element of the invention of claims 1 and 2 in Estes, Jr., and has therefore requested that the Examiner specifically point out in Estes, Jr. the occurrence each element of the inventions of claims 1 and 2. The Examiner has not done so. As a result Applicant is unable to direct the Board's attention to those portions of Estes, Jr. that the Examiner contends disclose each and every element of the invention of claims 1 and 2.

VIII. ARGUMENT
37 CFR §1.192(c) (8)

On p. 4 of the Examiner's Answer, the examiner has more clearly stated the grounds of rejection. The following arguments are in response to these grounds of rejection.

Examiner's rejection states that amplifier 175 in Fig. 2 of the Estes reference anticipates the amplifier recited in claim 1. In order to anticipate the claimed invention, "every element of the claimed invention must be identically shown in a single reference. ... T hese elements must be arranged as in the claim under review." *In re Bond,* 910 F.2d 831 (Fed. Cir. 1990). Therefore, in order for Estes, Jr. to anticipate claims 1 and/or 2, "every element of the claimed invention must be identically shown in a single reference. ... These elements must be arranged as in the claim under review." *Id.*

In order to anticipate either of claims 1 and 2, therefore, Estes, Jr. must set forth every element of the claims at issue, and those elements must be arranged as claimed. Claim 1 sets forth, *inter alia,* the following limitations and arrangement of elements, notably the "amplifier", which Estes, Jr. must teach and show in the identical arrangement:

Limitation 1: said output sampler functioning to provide a scaled sampling of the output voltage of said power line conditioner to a first input of said amplifier,

Limitation 2: said voltage reference connected to provide a desired voltage to a second input of said amplifier;

Limitation 3: an output of said amplifier connected to a first terminal of said first secondary winding of said isolation transformer,..., s aid second terminal of said first secondary winding of said isolation transformer also constituting the output of said power line conditioner.

The examiner's asserts that limitation 1 is met by the portions of Estes, Jr. comprising elements 136, 140a, 140b, 138 and 168, which are connected to a first input of amplifier 175. Examiner also argues that limitation 2 is satisfied by the ground connection to the second input of the amplifier 175 as taught in Estes, Jr.

Assuming, *arguendo*, that the above arguments with respect to limitations 1 and 2 are correct, amplifier 175 taught by Estes, Jr. does not satisfy limitation 3.

Regarding limitation 3, the examiner's position is that the output of the Estes, Jr. amplifier 175 is connected via elements 167, 138 and 136 to a first terminal (the top terminal) of the secondary winding of the transformer 34. The examiner's position requires that elements 136 and 138 are components of the output sampler as well as intervening components that facilitate the coupling of the output of amplifier 175 to the secondary winding of transformer 34. Those skilled in the art would immediately see that the use of elements 136 and 138 for facilitating the amplifier's connectivity requirements of claim 1 are inconsistent with the circuit claimed in claim 1. Estes, Jr. therefore does not teach each and every limitation of claim 1, and in fact teaches away from the invention of claim 1 by disclosing a circuit configuration that would render the claimed circuits inoperable as a power line conditioner.

The MPEP states that "During examination, statements in the preamble reciting the purpose or intended use of the claimed invention must be evaluated to determine whether the recited purpose or intended use results in a structural difference ... between the claimed invention and the prior art. If so, the recitation serves to limit the claim. ... If a prior art structure is capable of performing the intended use as recited in the preamble, then it meets the claim." (see MPEP 2111.02). Regarding the preamble, the examiner states (first full paragraph on p. 8 of the Examiner's Answer) that one skilled in the art would deem it reasonable to consider converting a square wave source into a triangle wave output to be power conditioning. However, the examiner provides no evidence in support of his assertion. Appellant submits that one skilled in the art would know that the function of a "power line conditioner" is always to remove spectral impurities from an AC power line so as to provide power that is substantially sinusoidal and devoid of harmonic, spurious and random noise components. Therefore, the examiner's interpretation of the term "power conditioner" in the preamble is overly broad and is outside of the "broadest reasonable interpretation" of the claim. For examples of the definition of the term "power line conditioner" as it is used in the art, see Appendix B, last two paragraphs of p. 1 and the first paragraph of p. 2 and Appendix C, third paragraph on p. 1. Appendices D-H are examples of websites that sell power line conditioners or contain definitions of power line conditioners.

It has long been the standard that the preamble is considered for purposes of determining anticipation or infringement when the preamble is necessary to give life, meaning and vitality to the claims. The Federal Circuit has also stated: "In other words, when the claim drafter chooses to use both the preamble and the body to define the subject matter of the claimed invention, the invention is so defined, and not some other, is the one the patent protects." *Bell Communications Research, Inc. v. vitalink Communicaitons Corp., 55 F3d 615* (Fed. Cir. 1995).

In this case, the intended use recited in the preamble is as "a series active power line conditioner". Estes, Jr. is not capable of functioning as "a series active power line conditioner", as that term is defined in the art, and therefore does not anticipate the claims at issue. This intended use of the claimed invention is reflected in a structural difference between the claimed invention and the prior art, and should therefore limit the reasonable interpretation of the terms in the claim to differentiate Estes, Jr. The following paragraphs explain these structural differences, and why the circuit taught in Estes, Jr. does not anticipate the claimed invention.

In order for the circuit described in the body of claim 1 to perform as a power line conditioner, the connection between the amplifier output and the first terminal of the transformer secondary winding cannot be connected to the output sampler. The output sampler cannot be included in the path between the amplifier output and the transformer secondary without forfeiting the functionality of the circuit as a power line

conditioner. All control systems operate on the general principle that an output is sampled and compared with a standard of desired behavior. The difference between the sampled output and the standard is called the error. The error is amplified and used to correct the system behavior. The gain of the amplifier is used to mitigate the error so that the behavior of the system is congruent with the standard. In the case of the power line conditioner, the output sampler allows the amplifier to compare a sample of the output voltage with the reference (desired) voltage. The gain of the amplifier is used to correct the output by minimizing the difference (error) between the sampled output voltage and the reference voltage. If the sampler includes connections to the output of the amplifier, as is the case when any part of the sampler constitutes a path between the amplifier output and the transformer secondary, the sampler does not function as intended. It does not provide a scaled sampling of the output voltage (limitation #1). It is corrupted by the amplifier output so that the amplifier no longer produces the correct voltage required to remove distortion from the incoming AC power sinusoid.

The power line conditioner of the present invention is a control loop or "servo". Referring to figure 4, the circuit will act to produce a voltage at output 501 that is a scaled replica of the reference AC voltage applied to the non-inverting input of the amplifier. The power line conditioner operates entirely on the principle that the reference voltage is a pure sinusoid and that the circuit will act to produce a scaled replica of the reference voltage at its output, thereby providing low distortion sinusoidal AC power at its output. If the reference voltage were 0V, i.e. ground, the circuit would

be useless because it would generate an output voltage of 0V. Therefore, a structural difference between the present invention and the Estes, Jr. reference is that, in the present invention, the second input of the amplifier cannot be connected to ground as taught in Estes, Jr., since connection to ground would transform the power line conditioner of claims 1 and 2 into merely an elaborate ground connection.

This indiscriminate, broad reading of claims, to the exclusion of the preamble, in order to bring the claimed invention within the teachings of a purported anticipatory reference has been repeatedly rejected. In *Corning Glass Works v. Sumitomo Electric U.S.A.*, 868 F.2d 1251 (Fed. Cir. 1989). At issue in *Corning* was a claim to optical waveguide. The claim at issue provided, in pertinent part: "An optical waveguide comprising (a) a cladding layer ... , and (b) a core formed of fused silica to which a dopant material has been added ... ." In rejecting the argument that the claim was anticipated by a reference that taught the combination of a core and cladding, but which did not and could not function as an optical wave guide, the Court stated:

> "To read the claim in light of the specification indiscriminately to cover all types of optical fibers would be divorced from reality. The invention is restricted to those fibers that work as waveguides as defined in the specification ... . [t]he claim preamble in this instance does not merely state a purpose or intended use for the claimed structure ...Rather , those words do give 'life and meaning" and provide further positive limitations to the invention claimed. ... [t]he core and cladding limitations ... are not the only limitations of the claim ... The claim requires, in addition, the particular structural relationship defined in the specification for the core and cladding to function as an optical waveguide." Id.

As in *Corning*, the preamble of claims 1 and 2 give "life and meaning" to the claims, and require that the claimed invention function as a power line conditioner. In addition, in order to anticipate, Estes, Jr. must disclose identical circuits that also function as power line conditioners. The structural differences aside, the Examiner's argument that Estes, Jr.'s reference voltage of "0" volts qualifies Estes, Jr. as "a power line conditioner" is "divorced from reality", and cannot be sustained.

Appellant submits that claims 1 and 2 are not anticipated by the Estes, Jr. reference and that claims 1 and 2 are in condition for allowance.

APPENDIX A
37 CFR §1.192(c)(9)

The text of the claims on appeal is:

Claims 1-25, as follows:

1. (Original) A series active power line conditioner, comprising:

an isolation transformer having a primary winding and a first secondary winding, said primary winding for receiving power from a source of alternating current power; and

a feedback control loop comprised of a voltage reference, an output sampler, and an amplifier, said output sampler functioning to provide a scaled sampling of the output voltage of said power line conditioner to a first input of said amplifier, said voltage reference connected to provide a desired voltage to a second input of said amplifier; an output of said amplifier connected to a first terminal of said first secondary winding of said isolation transformer, and a second terminal of said first secondary winding of said isolation transformer connected to an input of said output sampler, said second terminal of said first secondary winding of said isolation transformer also constituting the output of said power line conditioner.

2. (Original) The power line conditioner of claim 1 wherein the terminals of said primary winding of said isolation transformer are connected to a first port of the

power line conditioner, said first port also in communication with an AC power source; and

said second terminal of said first secondary winding of said isolation transformer wired to a second port of the power line conditioner, said second port adapted for connecting one or more loads to said second port of the power line conditioner.

3. (Currently Amended) The power line conditioner of claim 2 wherein said isolation transformer has a secondary unit, said secondary unit having a second secondary winding having current capability equal to that of said first secondary winding, ~~said second secondary winding~~ said secondary unit providing power to said amplifier of said feedback control loop, whereby voltage deficiencies in the incoming AC power are corrected by said amplifier utilizing the additional voltage contributed by said second secondary winding.

4. (Original) The power line conditioner of claim 3 wherein said amplifier is a differential amplifier having first and second inputs and an output port, said first input operating as a non-inverting input such that excitations presented to said first input are amplified by said amplifier with substantially zero phase shift, said second input operating as an inverting input such that excitations presented to said second input are amplified by said amplifier with substantially 180 degrees of phase shift; and

said output sampler wired between said output port of the power line conditioner and said inverting input of said amplifier, said output port of said amplifier wired to said first terminal of said first secondary winding of said isolation transformer, said second terminal of said first secondary winding of said isolation transformer constituting said output of the power line conditioner, the loop formed by said first secondary winding, said output sampler, and said amplifier operating to provide said amplifier with substantially negative feedback.

5. (Original) The power line conditioner of claim 4 wherein said output sampler comprises a voltage divider network.

6. (Original) The power line conditioner of claim 5 wherein said voltage reference is derived from a sampling of the incoming AC power and is substantially purified of harmonic, spurious, and random noise by a filter.

7. (Original) The power line conditioner of claim 5 wherein a passive network comprised of at least one capacitor is connected in parallel with said first secondary winding of said isolation transformer.

8. (Original) The power line conditioner of claim 7 wherein said passive network is comprised of a series connected resister and capacitor.

9. (Original) The power line conditioner of claim 4 wherein said output sampler is comprised of at least one resister and at least one capacitor, the gain of said output sampler being frequency dependent according to a time constant associated with said resister and said capacitor, the gain of said output sampler being measurably higher above than below a corner frequency associated with said time constant.

10. (Original) The power line conditioner of claim 9 wherein said output sampler contains a network comprised of a series connected resister and capacitor, said network connected between the input and the output of said output sampler.

11. (Original) The power line conditioner of claim 4 wherein a third input port is formed at a first terminal of a capacitor, a second terminal of said capacitor being connected to said non inverting input of said differential amplifier, said third input port being connected to the shield of at least one shielded cable by which connection is made between said differential amplifier and other components of said feedback control loop.

12. (Original) The power line conditioner of claim 4 wherein said differential amplifier is comprised of a integrated circuit operational amplifier and a high current push pull output stage, the output of said integrated circuit operational amplifier being

coupled to the input of said push pull output stage so as to form a differential amplifier of higher output current capability compared to the current capability of the integrated circuit operational amplifier.

13. (Original) The power line conditioner of claim 12 wherein a passive network comprised of at least one capacitor is connected to an output terminal of an active device used to perform amplification in said output stage and a terminal of a power supply used to bias said active device.

14. (Original) The power line conditioner of claim 13 wherein said passive network is comprised of a series connected resister and capacitor.

15. (Original) The power line conditioner of claim 12 wherein at least one diode is wired between the output of said integrated circuit operational amplifier and the input of said output stage, the polarity of said diode determined so as to permit the passage of output current from the output of said operational amplifier to the input of said output stage, the same polarity also providing blockage to current associated with the quiescent bias conditions of active devices used within said output stage to perform amplification.

16. (Original) The power line conditioner of claim 6 wherein said filter utilizes a voltage comparator for compressing a sampling of the incoming AC power into a substantially square wave.

17. (Original) The power line conditioner of claim 16 wherein a first and second power supply rail of said comparator is derived from the output of a first and second operational amplifier, respectively, the outputs of said operational amplifiers being wired to their respective inverting inputs so as to provide a voltage follower function in each of said operational amplifiers.

18. (Original) The power line conditioner of claim 16 wherein said voltage comparator operates from rail voltage supplies that are derived from a sampling of the incoming AC power in such a way that said rail voltage supplies effectively track the amplitude of the incoming AC power, the end result of which is a voltage comparator whose square wave output tracks the average amplitude of the incoming AC power.

19. (Original) The power line conditioner of claim 6 wherein said filter includes at least one operational amplifier configured to operate as a low pass filter.

20. (Original) The power line conditioner of claim 6 wherein said filter includes at least one 8th order low pass active filter.

21. (Original) The power line conditioner of claim 6 wherein said filter includes at least one passive resister-capacitor low pass filter.

22. (Original) The power line conditioner of claim 6 wherein said isolation transformer includes third and fourth secondary windings, said third secondary winding having substantially identical number of turns as said first secondary winding, said fourth secondary winding having substantially identical number of turns as said second secondary winding, wherein also,

said feedback control loop appears in duplicate as first and second feedback control loops, said first loop connected to said first and second secondary windings of said isolation transformer to form a first half of a balanced output power line conditioner, said second loop connected to said third and fourth secondary windings of said isolation transformer to form a second half of said balanced output power line conditioner, said third and fourth secondary windings of said isolation transformer connected to said second half of said balanced output power line conditioner in opposite phase with respect to said first half of said balanced output power line conditioner, said first half and said second half operating together to provide a balanced output voltage with respect to a common ground connection between said first half and said second half, without respect to the balanced or unbalanced nature of the circuit associated with said primary winding of said isolation transformer.

23. (Original) The power line conditioner of claim 22 wherein said voltage reference includes a phase splitter functioning to provide antiphase outputs from said voltage reference, said phase splitter being comprised of a first operational amplifier wired as a conventional non-inverting amplifier, and a second operational amplifier wired as a conventional inverting amplifier.

24. (Original) The power line conditioner of claim 22 wherein a first passive network including at least one capacitor is wired between a first output of said balanced output power line conditioner and said common ground, and a second passive network including at least one capacitor is wired between a second output of said balanced output power line conditioner and said common ground.

25. (Original) The power line conditioner of claim 24, wherein said first and second passive networks include at least one series connected resister and capacitor.

CONCLUSION

The Appellant requests favorable consideration by the Board. If any questions remain, please call the undersigned.

Respectfully submitted,

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Dated: January 14, 2004

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Juice From Cans

A Look At AC Power Conditioners — Part 1

DANIEL SWEENEY

Introduction

Among the reviewing community, AC power conditioners generally have not aroused a great deal of fervor—witness the fact that George Tice, the man who introduced the category to consumer electronics, is now much more celebrated for his mysterious time pieces than for the relatively straightforward Power Blocks. I am afraid that I must count myself among the unaroused, for in all of my 15 years of reviewing, I have never reported on such a device, nor have I wanted to. I always assumed that there was at least some slight value to the things, if for no other reason than they had earned a place in professional sound long before their appearance in audio boutiques, but my limited exposure to them was not replete with the kind of revelatory experiences that sustain conviction.

Curiously, however, almost none of the consumer power conditioners on the market have any provisions for controlling powerline voltage.

Nor, I must say, has earlier reportage been such as to inspire experiments on my part. "Yup. It works," has been the usual response of reviewers hapless enough to be assigned these items (mostly audio reviewers, as it happens, since video journals have largely ignored the category). Granted, such assertions might be occasionally followed by reports of such predictable epiphenomena as grain reduction, improvements in pace and even a wholesale redistricting of the soundstage—in other words, the usual accolades bestowed upon just about any audio accessory these days—but almost entirely absent in previous considerations has been any discussion of how such devices actually condition the alternating current from the wall or how such conditioning might affect the operation of audio or video equipment.

A curious omission, I must say, since power conditioners, unlike Shakti Stones and Mpingo disks and sundry other high-end anodynes, draw upon a well-established subdiscipline within the field of electrical engineering. Power quality, the engineering term for the degree of conformity of AC electrical power to the sine wave ideal, has been the subject of countless learned conferences and scientific papers, and is an area of increasing concern to electrical utilities themselves. In short, a lot is known about disturbances in utility AC waveforms and how such disturbances manifest themselves at the equipment interface.

What's To Be Conditioned — The Nature Of Residential AC Power

The alternating current provided by public utilities in the United States is transmitted to the residence at 60Hz and at a nominal RMS value of 120 volts. It is transmitted directly from the generator plant to various substations at much higher voltages over high tension lines in order to minimize resistive losses, but is stepped down via transformers prior to reaching residential users.

The frequency stability of the current provided to the residence is normally quite good, though not perfect, but the actual voltage at the wall socket frequently departs from the standard figure with numerous untoward consequences regarding the performance of home entertainment equipment. Curiously, however, almost none of the consumer power conditioners on the market have any provisions for controlling powerline voltage.

The AC itself is supposed to be a pure 60 cycle sine wave, but it generally contains quite a number of higher frequencies—albeit at much lower energy levels than the 60Hz fundamental. These are distributed across the audio spectrum, but their intensity is generally inversely proportional to frequency—that is, additional frequency components are stronger in the lower frequency ranges. Because the spurious energy on the powerline carrier is so broadband—and so generally unpredictable—it is quite difficult to eliminate.

AC in the residence swings from a positive value to neutral, zero volts representing the trough of the negative half cycle. Voltage is not supposed to swing negative at all in relation to ground, and thus the power circuit can be said to be single-ended. As I'll explain a bit later, a balanced power delivery to the residence, that is, a swing from a positive to a negative voltage, would conduce to better performance in audio and video systems, but it can only be had by resorting to some expensive expedients.

Hot positive and neutral are represented, respectively, by the left and right input slots on the AC wall socket. The third terminal, which is located between and below the two slots, is designated ground, or, safety ground. This is also supposed to lie at an effectively zero voltage potential, but unlike the neutral, it does not form a return path for current back to the terminal box of the residence. Instead it forms a path to ground—literally the ground beneath you—for dangerous voltage potentials that may develop on the chassises of electrical or electronic components. In other words, it functions analogously to a lightning rod, and often, like a lightning rod, the ground will be fastened to a metal object lodged in the soil, frequently a water pipe.

The Fix

So what is the role of the AC line conditioner in the provisioning of electrical power to the components in a home theatre system? The conventional wisdom, as expressed in much of the advertising copy for these devices, is that the AC should be "pure," that is, bereft of additional frequency components above 60 cycles, and that the primary role

Indeed, some of the statements by line conditioner and audiophile power cord manufacturers treat the AC power carrier almost as a signal itself, though in actuality wall current conveys no information.

of the power conditioner is to ensure such purity. Indeed, some of the statements by line conditioner and audiophile power cord manufacturers treat the AC power carrier almost as a signal itself, though in actuality wall current conveys no information.

Still, there is some truth to the conventional wisdom. A pure, sinusoidal 60 cycle current is in fact desirable—at least in theory

— but unfortunately, no consumer power conditioner, with two possible exceptions considered below, can output a 60 cycle sine wave. And, in any event, amplitude variations in the power AC are of more significance than are frequency variations to the performance of AV equipment, because over and under voltage conditions can result in gross malfunctions or even failure in electronic equipment.

So how much impact does spurious high frequency energy, as opposed to line voltage fluctuations, really have on the performance of audio and video components?

That's largely dependent upon the design of the equipment, particularly the design of the power supply.

The conventional "brute force" linear supplies used in most premium component audio and video products today are designed to rectify AC into DC and eliminate all sinusoidal wave forms, but they're more effective at some frequencies than others. They're most effective at the power frequency, 60 cycles, and at low multiples of that frequency—what are known as the ripple frequencies. They're less effective with ascending frequency.

Thus, competent power supply engineering goes a long way toward keeping powerline disturbances out of signal circuits. Nevertheless, polluted AC is not without consequences to AV system performance, nor is line conditioning worthless as some in the audio press have suggested.

However, push-pull circuits, ubiquitous in component audio and video today, have considerable ability to "reject" the power supply, that is, to keep power supply disturbances of whatever frequency from contaminating the signal. Then too, competent designers of linear power supplies generally add bypass capacitors to the supplies which act to shunt high frequency energy to ground.

Furthermore, almost all power supplies used in modern audio and video components are fully regulated—the exception being the supplies used for the output stages of power amplifiers. This means that voltages seen by the signal circuits are controlled by regulator circuits which are designed to reject residual AC in the power supply itself. And, in any case, the signal circuits themselves tend to be far greater offenders in terms of injecting higher frequency AC components into the supply than is the powerline.

Switching power supplies, used in cheap CD and DVD players, in some digital components, and in a few power amplifiers such as the Sunfire and Carver Lightstar units, are even more effective than linear supplies in keeping AC powerline disturbances in abeyance. Such power supplies perform what is called a dual conversion by rectifying AC from the wall, chopping the resulting DC into a ultra-high frequency AC power carrier, and then rectifying that back into DC. Nothing on the powerline itself is likely to make it through the chopper, though the chopper itself generates a great deal of high frequency noise. Fortunately, that noise is confined to ultrasonics, and thus arguably is easier to deal with than the broadband noise in a linear supply.

Thus, competent power supply engineering goes a long way toward keeping powerline disturbances out of signal circuits. Nevertheless, polluted AC is not without consequences to AV system performance, nor is line conditioning worthless as some in the audio press have suggested. What I will say is that most promotional literature for line conditioners and most reviews of the same have tended to be simplistic, misleading, and often downright false, hence my decision to write this article.

As I hope to demonstrate, the mechanisms of powerline interaction with electronic components are many and complex, and individual components vary greatly in their susceptibility to performance degradation in the face of compromised AC power. Seldom have previous considerations of the subject done justice to the complexity of the issues.

At times one almost suspects a conspiracy between manufacturers and reviewers to promote as much misinformation on the subject of power quality and conditioning as possible. Typically, power conditioners are presented as magic bullets which will somehow bring about wonderful improvements in sound image, dynamic range, system resolution, etc., often in seeming defiance of accepted electrical principles and with absolutely no reference to what actually might be occurring on the circuit level. Moreover, many of the manufacturers refuse to provide any specifics as to how their equipment operates, and make claims which strain credibility to the utmost. Very interestingly, most of the purveyors of audiophile and videophile power conditioners have zero presence in the industrial and medical markets where power quality can be literally a matter of life and death.

Even more interestingly, one finds within the serious industrial markets devices which can actually provide pure, noise free, sinusoidal AC power—devices which are completely unknown to most high-end reviewers. Multi-kilowatt, ultra-high performance uninterruptible power supplies from SanRex and Toshiba actually will maintain rock steady, 60Hz 120 volt sine wave power regardless of what the utility is providing. Such devices aren't cheap, but they're no more expensive than certain audiophile line conditioners of entirely unproven value. But as one consumer manufacturer who will go unnamed told me, "ordinary electrical principles don't hold in high end audio. It's a separate reality. I don't care if some meter says that a Toshiba UPS puts out perfect sine wave power, and my device doesn't change the current at all. I know that mine works and that the Toshiba screws up the sound." This statement coming from a manufacturer whose product was judged practically worthless for correcting power factor by a major utility, but at the same time was given rave reviews in several high end journals.

Maybe he's right. Maybe physical laws are somehow suspended in high end entertainment systems and that magic is more powerful than engineering.

But then again, maybe not.

Catalog Of Horrors

The following section identifies the specific disturbances that occur in AC power lines and illustrates how these can eventually be manifested in the output of the audio system, either through the passage of electrical interference directly into the signal path or by causing components to malfunction.

I would emphasize here that this distinction is fairly fundamental if not perhaps not immediately obvious. A component passing interference is not necessarily misbehaving or malfunctioning, in fact, it can be very linear. On the other hand, a component that is actually malfunctioning due to powerline perturbations is not necessarily subject to electrical interference, that is, the signal path itself may remain uncontaminated. Interference is an intrusion, a breakthrough at some point in the system where spurious electrical energy is conveyed into the signal path, and it may have nothing to do with component malfunctioning. In contradistinction, misbehavior due to shifting electrical parameters in the AC power waveform does not represent a breakthrough or intrusion, but rather a failure of the misbehaving component to amplify, process, or transduce a signal accurately because operational voltages derived from the power line are no longer within specifications for that given component.

Although they are certainly related, electrical interference riding on the powerline, and, conversely, destabilizing voltage and current fluctuations giving rise to equipment malfunctions, represent distinctly different sets of problems at the equipment level, and each has distinctly different audible consequences. Electrical interference tends to engender audible noise, while fluctuating voltages tend to change gain factors, or to introduce data or timing errors, or, in extreme cases, may even precipitate catastrophic failure. Both interference and instability often

occur in tandem, and often from the same cause, but their ultimate manifestations in the form of degraded audio or video reproduction are subjectively and measurably different. Noise is noise, a background that is recognizably different from the program. Distortions induced by powerline irregularities are more subtle—a loss of detail, video artifacts on the screen, a coarsening of instrumental textures, an unexpected harshness—almost anything, depending upon the design of the equipment and the nature of the powerline fluctuation.

Large Scale AC Disturbances

Since significant power AC voltage fluctuations can effect the longevity of components as well as the quality of reproduced sound, let us consider this type of aberration first.

AC fluctuations logically occupy two fairly distinct categories, the one being comprised of simple variations in AC voltage level, and the other of changes in AC power factor, a term defined below. Both may have significant impact on audio and video reproduction.

Over And Under Voltage

The first category consists of over and under voltage conditions where the rms voltage of the alternating current exceeds or falls below a predetermined range. North American public utilities nominally transmit 120 volt power into residences, but actual voltages at the wall terminal typically fall somewhat below that figure on a long term basis due to various losses in the power system. This is to be expected, and is of no great significance so long as the droop does not exceed a few volts, but what is cause for concern are violent moment to moment fluctuations in voltage level, or, alternately, long term plateaus above or below certain maxima and minima.

All competently designed audio components are tolerant of slight long term departures from the nominal 120 rating, with 110 volts representing a sort of generalized minimum and 130 an absolute maximum. Furthermore, practically all components can endure brief voltage swings of much greater magnitude; in fact, most components can tolerate momentary surges of several hundred volts. On the other hand, most audio and video systems are relatively intolerant of what are known as sags and swells, voltage fluctuations of moderate magnitude lasting for seconds; and amplifiers particularly exhibit audible changes in gain in the midst of such deviations.

Severe surges, those exceeding a kilovolt, are of particular concern to designers of AV equipment. Such events can destroy equipment in milliseconds, and they occur more frequently than most people realize—scores of times a month according to some studies. In fact, surges exceeding 5,000 volts are not unknown. Unfortunately, many line conditioners on the market provide no protection whatsoever against destructive surges, and most designated surge protectors are severely limited in their ability to provide protection against repeated surges. Because this topic is so vitally important, we'll return to it later.

Interestingly, no audiophile line conditioner, with one exception—the $3,000 MSB Power Plant, which really isn't a line conditioner in the strictest sense—has been designed to maintain constant voltage levels in the face of sags, swells, and surges. To obtain this benefit, you have to resort to industrial equipment. More on this later.

Degraded Power Factor

The next class of powerline problems consists of harmonics and the interrelated phenomenon of degraded power factor. These sorts of disturbances occur when the AC terminates into a reactive load, one that causes voltage and current to depart from the ideal 90 degree phase relationship. Reactive loads, that is loads representing either a capacitance or an inductance, engender lags in either voltage or current which in turn change the shape of the waveform and superimpose higher frequencies upon it, those representing the sequence of phase lags. These additional frequencies are termed harmonic distortions, and are exactly analogous to the distortions produced by an amplifying circuit.

An AC waveform that has been distorted by reactive impedances has what is known as a low power factor, that is it does not preserve the proper relation of voltage and current that permits efficient power delivery to the electrical appliance. Motors particularly are adversely affected by poor power factors, but so, to varying degrees, are analog audio circuits and digital circuits of all types.

Most modern residences are full of reactive loads, and these include motors, fluorescent lights, switching power supplies on computers, transformers and solid state rectifiers, to name just a few. Audio and video components themselves form reactive loads, and so you literally pollute your AC simply by turning on your system. Even with everything off, the AC flowing into your home may manifest anywhere from two to five percent harmonic distortion, and after circulating through your house wiring, that figure may rise to 10 percent or more.

On this note, it is entirely possible to believe that George Tice's famous clock really does exert a readily explainable audible effect, at least on certain components. Whether that effect is beneficial to fidelity is debatable, however. Any motor will cause some degradation in power factor, and that couldn't possibly be for the better. It could create an audible difference, though, and to some ears different is always adjudged better.

At any rate, you should be aware that most line conditioners on the market don't begin to address the harmonic and power factor problems. Because of the magnitude of the currents involved, and the fact that distortion is concentrated in the lower frequency ranges, passive power correction and filtering of harmonics must involve enormous, lossy electrical components to be very effective. Furthermore, since harmonics occur at octave intervals, in order for filtering to be thorough, it must be either broadband or must alternately utilize multitudes of high Q, narrow band trap circuits. Either way entails a lot of huge, high value components, and you're not going to fit all that componentry into the trim little boxes that house the innards of most audiophile power conditioners. Think of the size of the components necessary to construct a passive 100Hz loudspeaker crossover, and then consider the fact that wattages involved in AC power transmission are many times greater than the power transmitted over a speaker cable. Thus, given their dimensions, most black box audiophile power conditioners are only capable of filtering high frequency hash, and can have only the most negligible effect on power factor.

I must mention, however, that there are a couple of passive devices whose manufacturers claim can effectively filter low frequency harmonics. These include the Burmeister line conditioner and the MIT Suite of line conditioners (apparently more than one black box is required). I have not tested any of these devices, so I can't comment on the validity of the representations. All I can say is that conventional passive filters must involve large high value components in order to be effective. Let the buyer beware.

There are also, I might add, specific power factor correction devices selling in the industrial market (considered below), that are undeniably effective, but all such devices I've seen are very expensive, generally priced in the thousands of dollars. With the price of pure power that high, it probably makes more sense in most instances to invest in components designed with a high tolerance for impure power, but that's an individual decision. And bear in mind that the single ended amplifiers beloved of many audiophiles are especially vulnerable to low frequency harmonics. If you've got to have one of those, you might want to look at an industrial solution.

Minor Disturbances — Electrical Noise On The Line

Our next primary category of disturbance is electrical noise, that is, additional frequencies unrelated to the 60 cycle power carrier. I call this disturbance minor only by virtue of

its magnitude in relationship to the 60 cycle waveform. In terms of its effect upon the quality of sound and video reproduction, electrical noise on the powerline can represent a very major problem indeed.

Normally what we're concerned about here is high frequency noise, which often extends up into the Megahertz. Commonly the term noise is also applied to 60 cycle hum, but only in certain cases does such hum arise from a noise component present on the powerline. Since the power AC is itself 60 cycle, even the purest wall current can engender hum if that AC can find ingress into audio or video circuits, and when that occurs the hum must properly be considered an audio equipment problem not a powerline problem. Only when 60 cycle AC voltages are present on the safety ground can 60 cycle hum properly be construed as a powerline noise problem. Nevertheless, I shall have something to say about hum arising from equipment problems as well as that attributable to powerline contamination simply because the audible manifestation of each is exactly the same, and because troubleshooting for powerline hum on the safety ground necessarily involves ruling out hum at the component level.

Electrical noise on the powerline arises from a great variety of sources. Electrical and electronic switches are prime contributors as are rectifiers and motors, the same culprits behind much of the harmonic distortion on the line. But powerline noise, unlike poor power factor and voltage fluctuations, normally does not disturb the basic operation of either audio circuits nor motors. Its usual adverse effect is contamination of the audio or video signals.

Since noise is generally the most noticeable type of powerline impurity and the most difficult to eliminate, it is well to understand how noise is transmitted from the powerline to the audio circuitry and ultimately to your eyes and ears.

Electrical noise on a powerline takes two forms, normal mode noise and common mode noise. Normal mode noise is propagated between hot and neutral, that is, it rides directly on the power AC waveform. Common mode noise, on the other hand, is developed across the potential between the neutral conductor and the safety ground.

The magnitude of normal mode noise is commonly much, much greater than that of common mode noise, but, paradoxically, the common mode variety is apt to pose much more of a problem since, in the case of third pin safety grounding, the safety ground conducts directly to the chassises of your components and from thence to the RCA signal ground (RCA interconnect cables are normally grounded directly to the chassis). Generally impedances on the safety ground are such that the level of interference is low, but when you're dealing with line level signals that are a fraction of a volt, it doesn't take much interference to produce audible or visible consequences.

Contrary to many uniformed statements in the consumer electronics press, electrical noise, specifically normal mode noise, generally does not take a direct route through the AC power cord and into the power supply and thence into the audio or video circuits. That's because the design of the power supply is such as to eliminate or drastically attenuate almost entirely all AC fluctuations of whatever frequency. Rather, noise tends to enter the audio signal path by less direct routes.

Capacitive coupling between the power cord and the chassis or the power transformer and the chassis is one mode of noise transmission. Capacitive coupling can also involve audio or video circuits directly, though the chassis itself is normally the vehicle for conveying noise into the signal circuitry. The actual gateway where noise will pass into the signal path will usually be at the RCA output jacks since the outer sleeve or ground terminal is attached directly to the chassis. Thus any potential on the chassis will give rise to a current in the ground conductor of the RCA interconnect and ultimately to a modulation of the audio or video signal.

Be aware that this same noise gateway can create problems even with the purest AC power. All power transformers within power supplies have capacitance between the primary and secondary windings, and this capacitance will couple to the chassis and transmit 60 cycle through the chassis. Some power transformers are provided with copper shields to minimize such coupling—an excellent idea that all manufacturers should embrace—but even with that, some coupling will occur. The best way of dealing with the problem is to separate the power supply from the main chassis and convey the regulated DC to the signal circuits via an umbilicus, but unfortunately such construction techniques greatly increase the cost of a component and thus aren't commonly used even in the most esoteric pieces. Thus, for most of us the basic design of the components presents a basic problem.

AC hum, or "hum bars," in the case of video, can also arise from the failure of power supply components, particularly filter capacitors, or from poor circuit board layout. In such cases, no amount of attention to interconnect cables or powerline purity can remedy the situation, and repair or modification of the component is the only solution to the problem.

Apart from the provision of an entirely separate power supply, a "dirty chassis" condition arising from capacitive coupling from the power transformer can be addressed by two other design techniques, the use of balanced circuits and connectors in the signal circuitry, and by third pin grounding on the power cord.

Fully balanced circuitry, including balanced connectors, effectively blocks most AC coursing through the chassis or the safety ground because it provides no point of entry of noise from the ground. It also, as we shall see, enjoys an extraordinary immunity from induced and radiated noise, defined below. However, except in the case of Servodrive, Inc.'s balanced choke interface, a new type of accessory discussed below, XLR interconnect cables are mandatory for the achievement of a fully balanced signal path.

Third pin grounding, the second cure, may be used with either balanced or single-ended circuits. In this arrangement a third pin conductor on the power cord serves to drain the chassis of AC potentials, and thus attacks the noise problem at its source.

Here I might note that third pin grounding flies in the face of audiophile folklore where the recommendation is to lift the grounds. Sometimes, in fact, lifting one or more third pin grounds in the system will serve to reduce hum, but such will be the case only if a potential is present between neutral and ground—an undesirable but by no means uncommon state of affairs. In any case, lifting a ground is apt to create more problems than its solves, particularly when it is done at only one point in the signal chain. In any pairing of components where one component is third pin grounded and the adjacent component is not, the RCA cable connecting them will be transformed into a grounded antenna poised to pick up all manner of radiated or induced interference in the air. If, on the other hand, the AC safety ground is truly at ground potential, AC on the chassis will seek ground through the grounding pin instead of flowing up the RCA neutral to be amplified in the next stage, and, moreover, the RCA cable will cease to function as a radio antenna. To repeat, third pin grounds need not be portals for noise; properly implemented, they will actually reduce noise.

With an optimized AC power system, where ground is really ground, third pin grounding should be provided for all components—and not only for sonic reasons. In the event of a massive component failure, a third pin ground will serve to drain dangerous voltages from the chassis. This is particularly important when you're dealing with tube electronics where supply rails sit at hundreds or even thousands of volts, and where power supply capacitors have been known to burst and release their charges onto the exposed metal surfaces of the chassis. Such potentials can kill you or a family member or a pet—something to think about. Something else to think about is that practically no audiophile tube gear is rated by Underwriters Laboratory for safety.

Undeniably, though, noise can enter an audio signal path through the third pin or safety ground even though that ground is intended to serve as drain and as means of

eliminating noise. If a significant voltage potential is present anywhere in that ground path, then current may flow back up the grounding wire and into the signal path via the RCA neutral, and you'll have what is commonly known as a "ground loop." The most obvious indicator of a ground loop is the presence of audible 60 cycle hum, but higher frequency noise can course up through the third pin ground wire as well.

A particularly insidious kind of electrical disturbance that can attack components through the third pin ground results from the use of MOV (metal oxide varistor) or gas tube type surge suppressors. These devices serve to shunt the excessive voltages that occur during surges, but since the voltages have to go somewhere, they generally appear on both the neutral and the safety ground. By providing a double shunt, from hot to neutral and then from neutral to ground, the voltage is divided twice and thus is considerably reduced, but the voltage shunted to safety ground can then appear on the chassis via the safety ground. Digital circuits particularly are prone to malfunction in the presence of such reverse ground currents.

Can power conditioners deal with this vexatious problem of noise on electrical grounds? Indeed, some of them can, particularly those utilizing an isolation transformer that breaks any direct connection with the safety ground, and establishes an effective zero potential at the secondary of the transformer for all components drawing current from the transformer. However, any transformer that breaks the safety ground will not meet UL requirements and will not divert dangerous voltages on component chassises in the event of equipment failures.

House wiring that is meticulously installed to meet and exceed code and which utilizes low resistance copper wire rather than cheap aluminum Romex cabling will also go a long way in minimize ground noise, as will a very low impedance connection for the RCA ground conductor. Remember noise can occur at any point where a potential lies between a noise source and an open audio and video circuit, and so noise suppression techniques should be utilized system-wide.

Incidentally, the worst of all situations is one where a line level component in the signal chain has no chassis grounding and no proper shielding of the power transformer and where the RCA ground contact has developed a high impedance due to fouling. In such cases you can practically count on serious AC hum in your system.

While the safety ground and the RCA signal ground, which are, of course, connected, constitute the most usual pathway for noise contamination, they are by no means the sole means of ingress. Noise may also be induced by magnetic fields—transformers and AC power cords are major offenders in this regard—or, as we have seen, may be picked up antenna-fashion by interconnect cables from radiated radio frequency energy in the environment. Generally, however, the AC safety ground is the major thoroughfare for the passage of electrical interference into the system.

Classes Of Power Conditioners

The broad category of powerline conditioners contains several distinct subcategories which are differentiated from one another by principle of operation as well as by purported benefits. These subcategories include the following: simple surge protectors; isolation transformers; RFI filters; line voltage regulators; sine wave regenerators, including uninterruptible power supplies; power factor correction devices; others. These categories are not necessarily mutually exclusive, for instance, a line voltage regulator can also be an isolation transformer, but in most cases a line conditioner will be designed to perform one primary function and will use one specific technology to accomplish that function.

Power conditioners as a class of electrical equipment, are chiefly used in commercial applications, particularly in large data processing centers, in hospitals equipped with sensitive electronic monitoring equipment, and in automated manufacturing facilities where the error rate of data processing equipment must be strictly controlled. High end audio is tiny segment of the market. Incidentally, commercial power conditioning equipment is often very sophisticated but tends to be quite expensive, with some actively controlled power distribution modules priced in the tens of thousands of dollars. Consumer units with which I am familiar are less costly, and less sophisticated as well.

Surge Protectors

Practically all surge protectors on the market make use of shunt circuits placed across the hot, neutral, and safety ground conductors of the internal AC cabling. The shunts utilize any of three overvoltage protection devices which have the characteristic of opening up and lowering their resistance in the presence of voltages above a predetermined threshold. These devices are the avalanche diode (little used today), the MOV (metal oxide varistor), and the gas tube. All three of these devices are "sacrificial," that is, they lose their effectiveness in the presence of repeated high intensity surges and must be replaced, however avalanche diodes and gas tubes are more robust than MOVs. Unfortunately, there is no foolproof method for a consumer to determine if the useful life of the device is over unless the manufacturer has installed monitoring circuitry (a rare occurrence).

Most engineering texts on surge suppression take the position that MOVs fail gradually, losing their effectiveness by degrees. But Damien Martin, who heads Monster Cable's power conditioner design program, disputes this notion. "We've tested MOVs in old surge suppressors, and we've found that they fail catastrophically when they fail at all. Performance is not degraded gradually as is often stated."

Incidentally, the MOVs used in most surge protectors today will have a raw parts of cost of under a dollar, even in the case of the highest rated devices. Gas tubes, which are generally more reliable, but relatively slow acting, cost a couple of dollars. Thus if you're paying several hundred dollars for a surge protector using either of these devices—and some of them are priced that high—you're getting burned, let me assure you. You can buy unbranded surge protectors using the highest rated MOVs and gas tubes from bulk electronics suppliers for under thirty dollars, and that's your best bet if you don't want to move up to the next class of device, that utilizing avalanche diodes or series mode surge suppression.

Transsector is the leader in avalanche diode technology and has developed complex protection circuits based upon these devices that will guard against very short term transients of a few microseconds, as well as surges lasting up to a thousandth of a second. Transsector suppressors are widely used in industry, and the company claims useful life exceeding ten years. The downside is cost. Transsector products are much more expensive than MOV based suppressors.

Currently two companies make series surge protectors for the audio industry, New Frontier, located in New Hope, Pennsylvania, and Brick Wall, both licensing the same technology. Their modules use series filters consisting of high value capacitors and very large iron core chokes. The Surge-X products bearing the New Frontier name have been certified by Underwriters Laboratories to be capable of withstanding several thousand repetitive surges of six thousand volts and three thousand amperes, and they should be able to protect your equipment from almost any conceivable power hit including lightning strikes. They are expensive though, at several hundred dollars apiece and are aimed at recording and broadcast facilities. The Brick Wall products, targeted at the audiophile and home theatre markets, are a bit cheaper.

I have used the New Frontier device myself, in fact I own one, and I have not found it to alter sound or image in any way, when used by itself. Curiously, when I used the device in conjunction with the Equi=Tech balanced isolation transformer described below, it appeared to degrade sound quality very slightly.

Surge protectors as a class are commonly thought to affect sound quality, though there is no technical reason why such a

device should have any baneful effect on normal house current, provided that resistive losses have been kept to a reasonable minimum.

Surge suppressors are made by a considerable number of companies including Monster Cable, Panamax and Tripp Lite.

Isolation Transformers

These I have already touched upon earlier in the text. They are simply one-to-one transformers, which means that the primary and secondary windings are the same length so that voltage is neither boosted or reduced. Such devices break the neutral, and establish a new neutral reference at the ground of the secondary. They effectively prevent normal mode noise from entering an audio system.

Isolation transformers are made specifically for the audio community by Audio Power Industries (the Power Wedge), Exide, Monster Cable, Tice Audio, Furman, and Equi=Tech. Industrial models are made by Sola Heavy Duty, American Power Conversion, and others. The Equi=tech and Furman models use what are known as balanced power transformers, a design which deserves special mention. Monster Cable is currently developing a balanced transformer product as well.

Balanced power transformers feature center tapped grounds, and they transform the single ended 120 volts to ground AC power into balanced power swinging from 60 volts positive through ground to 60 volts negative. Total voltage swing is the same, but the voltage on each hot conductor is half the voltage on an unbalanced hot positive.

What's the point? Well, because the voltages are lower, capacitance between the primary and secondary in a component's power transformer is reduced by a factor of four. Thus any AC on the chassis is lowered by 6dB. Furthermore, any odd order harmonics produced by reactive loads fed by the transformer will be bucked out by the transformer, significantly improving the power factor of the AC being delivered to the components. Any normal mode noise generated by components will also be cancelled.

Balanced power has been used on naval ships for decades to improve AC quality, but has been previously almost unknown in audio. In researching this article I interviewed several engineers with expertise in noise suppression and or power supply design, and all agreed that balanced power was beneficial and should provide at least some noise reduction in an audio system. Equi=Tech claims typical signal-to-noise improvements of 16 to 18dB, with greatest improvements achieved when balanced power is combined with balanced line connections.

I was provided with a reviewer's sample of Equi=Tech's fifteen ampere isolation transformer by the manufacturer, and I found the reduction in noise to be dramatic. The system in which the device was inserted did not have an audible problem with 60 cycle hum, so it did not benefit in that regard, but the overall noise floor dropped by what I would estimate was 10dB. Dynamics appeared to increase correspondingly, and bass seemed more solid. High frequency transients such as cymbal hits had more sparkle and definition. I'm not going to say that the soundstage became five feet wider or that pitch became more accurate or some of the other claims advanced by other reviewers for other power conditioners because I didn't observe such phenomena. But the unit met manufacturer claims in reducing the noise floor, and that is simply indisputable. The noise coming out of the loudspeakers under no signal conditions dropped when the Equi=Tech was used as a power terminal—that simple.

On the other hand, the Equi=Tech created plenty of airborne noise because the transformer buzzed. I find that less objectionable than electrical noise, but that's the tradeoff.

One final note: isolation transformers are often said to squash the dynamics in sound reproduction, and such can occur if the transformer's electrical ratings are inadequate. The transformer's core must be sufficiently large to avoid saturation in the presence of high current draw, and the windings must contain sufficient wire so that temperature rise is kept to a minimum (elevated temperatures increase electrical resistance and dissipate power). In practical terms, a 15 ampere transformer (sufficient for most two channel home audio systems) must have an iron core exceeding thirty pounds in weight and must have a total weight exceeding fifty pounds. Many audiophile products of the past have been nowhere near that heavy, so it's little wonder that they would compress dynamics. But, as I indicated, the Equi=Tech had no such effect. Dynamics were actually improved.

Given adequate electrical ratings, there is no discernible technical reason why a well designed isolation transformer should compromise reproduction. But, as always, the truth is in the listening.

RFI Filters

These represent power conditioning at its most elementary, consisting of a trap filter (tuned to certain frequencies) or a low pass filter, either of which is intended to attenuate high frequency noise and distortion on the AC waveform.

Such devices are inexpensive to build, and are normally reasonably priced, but they have their limitations. As we have seen, passive filtering of low order harmonics is impractical, and so the simple line filter has little effect on the signal below 1kHz. Yet below 1kHz is where most of the bad action is, and normal mode noise and distortion above that point should be largely blocked by the power supplies of the components themselves if they're doing their job.

Neither do simple line filters address common mode noise on the ground, nor would you want to filter ground since the ground path must be kept at as low an impedance as possible in order to fulfill its role.

Defenders of the RFI filter type maintain that more effective noise suppressors, particularly isolation transformers, choke off current and squash dynamics, though since the power supply itself contains a transformer, it's difficult to accept that argument on technical grounds, provided, of course, that the amperage rating of the isolation transformer is adequate for the application.

RFI filters certainly aren't without benefit—they wouldn't be used in industrial applications if that were the case—but they're not panaceas either. They only address one problem in AC power quality, and that problem may not be a serious one in your system.

Line Voltage Regulators

Line voltage regulators make a lot of sense inasmuch as voltage sags and swells can definitely degrade audio and video system performance. But curiously only two audio or video oriented power conditioning products address the problem, and neither has found a significant market.

Line voltage regulators take several forms, the most common of which are ferroresonant transformers and switched tap transformers or autoformers.

The former are transformers designed to operate with partially saturated cores. Overvoltage conditions increase saturation and result in reduced efficiency, while undervoltages reduce saturation which boosts efficiency. Either way the transformer tends to maintain output voltage at a predetermined level, and, indeed, some of these devices can maintain 120 volt at the power plug with sags as low as 80 volts!

Unhappily, such devices cannot be heavily loaded, and do not provide satisfactory results driving high powered amplifiers. Hands-on audiophiles often experimented with these transformers during the eighties, but the devices quickly passed from favor.

The second type of regulator, the switched tap transformer, has a secondary with multiple taps—sometimes more than ten—that provides step up and step down in increments of a few volts. Taps are switched by active circuits connected to voltmeters, and, in the better designed models, will switch in one wave cycle at the zero crossing of the AC waveform.

Switched tap transformers or autoformers cannot maintain a rock steady voltage, but they can stabilize voltage to a considerable degree, and, where circuits are shared with motors and other current hogs, will almost certainly improve the performance of an audio system.

Furman currently makes one model of

switched tap autoformer aimed at the pro sound industry. Many industrial power conditioner manufacturers make these devices as well including Sola Heavy Duty, American Power Conversion, and MPI.

A number of other devices have been developed to regulate power, but all are bulky and expensive and are aimed at industrial rather than domestic users, so I shall pass over them here, except to mention the MSB Power Plant which more properly belongs in the next section.

Sine Wave Regenerators

Two of these devices are currently being offered to the audio enthusiast, the aforementioned MSB Power Plant and some optionally equipped models of the Equi=Tech balanced power transformers. Both work on similar principles. Industrial models are also available from a wide variety of vendors including Toshiba, SanRex, BEST, Exide, American Power Conversion, and others.

Sine wave regenerators, also known as uninterruptible power supplies or UPSs, differ from all other sorts of power conditioners in that they rectify the AC power sine wave into DC and then regenerate it from the stored DC. In other words, they're AC to DC to AC converters. Obviously by performing this process, these products completely eliminate any noise or harmonics on the powerline, and effect a total isolation from powerline disturbances, excepting noise on the safety ground.

Such devices have in the past utilized several different means of regenerating an AC waveform including combinations of silicon controlled rectifiers and capacitors, flywheel controlled electrical generators, and even large power amplifiers combined with 60 cycle oscillators. Today, however, all but the very largest UPSs on the market employ pulse width modulators driven by a 60 cycle clock. Thus the UPS might be said to be a class D power amplifier which amplifies but a single frequency, namely, 60 cycles.

UPS's vary considerably in the accuracy with which they reproduce a 60 cycle wave form. Low priced UPS's sold in electronic supply stores normally switch the carrier at low frequencies (within the audio range) and produce a staircase output wave form which is then smoothed through an output filter. Such devices may output a wave with as much as 10 percent THD. Higher quality UPSs, which are said to have a sine wave output, will switch at higher frequencies, with 48kHz representing the maximum in a commercially available product. The best of these, the Toshibas, are guaranteed to maintain distortion below 1 percent, which is considerably better than the AC supplied by utilities.

A few UPSs, such as the SanRex and Toshiba models, incorporate automatic power factor correction circuits which will adjust the output in the presence of reactive devices drawing power from the line. Such high end models also regulate voltage to within 1 percent. In sum, a high end industrial UPS will provide extremely clean AC power, handily outperforming any passive audiophile device of which I am aware.

So why isn't everyone using them? Obviously, most audiophiles and most retailers don't even know they exist. Another inhibitor is price. A top rated UPS capable of providing the amperage to run a high powered AV system will run a couple of grand minimally, a lot for an accessory. Finally, a big UPS will often require a 220 dedicated circuit.

AC line conditioning is of theoretical benefit, but measurable and perceptible results vary greatly according to the quality of the AC in the first place and the design of the AC components.

Power Factor Correction Devices

Power factor correction devices are normally installed by utility companies or by large industrial users of electricity. With the exception of the Seakay and USES products described below, none are consumer products.

Four principal technologies are used for power factor correction, simple shunt capacitor circuits, switched capacitor shunts, feed forward schemes, and sine wave regeneration. We can ignore the last since we have already considered it. The Seakay and USES products use an altogether different technique one covered in a recent patent. Incidentally Seakay is a licensee of USES.

Since poor power factors are usually the result of inductive loads, the addition of parallel circuits with capacitors tied to ground will normally improve power factor. If the problem is intermittent, sensors tied to banks of switched capacitors will provide more accurate correction.

Yet more precise correction may be accomplished by attaching a comparator circuit with a 60 cycle reference to the AC line and using a high powered class AB amplifier to amplify the difference signal and inject it antiphase into the powerline. A couple of such devices exist in the consumer audio market, the Accuphase models PS-1200 and PS-1500, the numbers referring to volt-amperes. I have tested neither device, but the principle of operation is sound, and I would expect that these conditioners would provide a significant reduction in line harmonics. Such devices were, at one time, available in the industrial market as well, but inquiries put to major power conditioner vendors yielded no evidence of current production models. My surmise is that sine wave UPSs have tended to obsolesce feedback correction schemes in the industrial sector.

The USES technology for power factor correction purportedly employs a completely passive implementation of the above processing strategy. Company representatives, citing fears that the circuit might be copied, refused to disclose the principles of operation. On the surface the technical claims advanced for the product seem highly implausible.

I was sent a Seakay Line Rover for evaluation, and found no benefit whatever from using it. I was not able to test the device with a line harmonic meter, but I contacted a USES reference, a New England utility. A technical staff member reported negligible power factor correction capabilities.

I must point out, however, that a number of reviewers writing for *Stereophile* and the old *The Absolute Sound* reported stupendous benefits from using this device. You never know.

USES also claims UL testing, not verified by UL, and the capability to protect against lightning strikes, not validated by any independent body. But what the hell, the thing only costs $1,800, which is chump change for most of us.

Other Devices

Now to our final category, which contains three devices which don't really fit into any of common groupings. Into this grab bag we place these products, the Chang Lightspeed, the Bybee Box, and the Servodrive, Inc. Ground Loop Eliminator.

The Chang Lightspeed is God knows what. I interviewed the designer, and he refused to discuss the principle of operation, claiming the technology was a trade secret. I've never tested the thing so I have no idea what it has to offer.

I do have some experience with the second accessory, the Bybee Box, invented by Jack Bybee of Bybee Technologies. Having interviewed Mr. Bybee at length, I can say that he unquestionably possesses a strong scientific background, but I cannot determine the validity of his claims.

Bybee states that his device addresses the problem of quantum noise, a low level electrical disturbance arising from the fact that individual electrons occupy discrete quantum potential energy levels, and that a drop from one level to another, as occurs continually, will result in a release of energy (measured electrical charge is the average of countless individual electron energy levels and does not reflect individual differences on the electron level). Such quantized releases of energy occupy specific portions of the spectrum and tend to be especially preva-

lent in the audio midrange. Incidentally, the generation of coherent laser light is based on just such quantum principles.

Bybee maintains that while the level of such quantum noise is low, it is none the less obtrusive in audio and video circuits. His devices purportedly filter quantum noise, though not by returning it to ground, as do filters consisting of inductors and capacitors, but rather by converting it into heat.

Bybee says that quantum filters were originally developed under Navy contracts in order to help monitoring equipment to pick out faint sonar signals buried in the electrical noise floor. He claims to have been employed by a Navy contractor in developing such filters.

Bybee's devices are expensive, and he himself admits that they don't seem to benefit some systems. I would advise a home audition before buying one. Nevertheless, I should say that the technology has been endorsed by two design engineers who I respect greatly: John Curl and Jennifer Crock. Incidentally, Bybee claims differences in AC caused by his device are measurable, though not by means of conventional power factor meters.

I tried one of the devices myself, a pre-production prototype. I did not notice an improvement or indeed any change at all.

The Servodrive, Inc. Ground Loop Eliminator, is not really a power conditioner in the strictest sense, but since it effectively addresses one of the most persistent and annoying problems in AV systems, it's worth a mention. Having signed a nondisclosure agreement, I cannot reveal the principle of operation except to say that the device incorporates a tweak that has been known to a few technically savvy audiophiles for decades, and that it is just as effective, if not more so than an XLR connection for breaking ground loops.

The Ground Loop Eliminator is a completely passive device placed between line level components. Prices depend upon the number of channels but are in the hundreds of dollars. It's not cheap, but construction involves some fairly expensive magnetic materials, and it really works.

Summing Up

AC line conditioning is of theoretical benefit, but measurable and perceptible results vary greatly according to the quality of the AC in the first place and the design of the AC components. RF filters, isolation transformers, and surge suppressors are valid accessories, though again effects are variable. Series mode and avalanche diode type suppressors should be used in lieu of the MOV type if one can possibly afford the former.

Top rated sine wave UPSs probably represent the ultimate in line conditioning but extremely high prices preclude their use in most systems. Finally, the buyer should exercise extreme caution in regard to devices based on mysterious principles of operation or claims which seem to fly in the face of standard engineering theory.

Part 2

In Part 2, we will look at several consumer application AC Power Quality Devices on the market and evaluate their performance on a home theatre system.

Manufacturers List For AC Power Quality Devices

1. Accuphase (sold through Axiss Distribution, Inc.): 17800 Main Street, Suite 109, Gardena, CA 90248-3500, 310 329 0187.

2. American Power Conversion: 132 Fairgrounds Road, West Kingston, RI 02892, 800 8004APC, 401 789 5735. APC specializes in microprocessor controlled-UPSs with advanced diagnostic and management features.

3. Audio Power Industries: 2624 South Rousselle Street, Santa Ana, CA 92707, 714 545 9495. Leading manufacturer of audiophile line filters; also active in industrial markets.

4. Best Power: P.O. Box 280, Necedah, WI 54646 800 356 5794, 608 5657200; Best specializes in small UPSs for PCs and telephones.

5. Brick Wall: 800 528 0313. Licenses New Frontier technology. Products aimed at audiophile rather than industrial markets.

6. Bybee Technologies, Inc.: 2072 Touraine Lane, Half Moon Bay, CA 94019, 650 726 9352. Manufactures a passive "black box" powerline conditioning solution, as well as noise suppressors for line level and speaker level interfaces.

Chang Lightspeed
Distributed by RCS Audio International: 3881 Timber Lane, Verona, WI 53593, 608 833 6383

7. Equi=Tech Corporation: P.O. Box 249 Selma, OR 97358, 888 AC SOURCE, 541 597 4448. Equi=Tech makes balanced isolation transformers and UPS/balanced transformer combinations.

8. Exide: 8609 Six Forks Road, Raleigh, NC 27615, 919 8723020. Major manufacturer of UPSs and transformers.

9. Furman Sound, Inc.: 30 Rich Street, Greenbrae, CA 94904, 415 927 1225. Caters to the professional sound market. Produces balanced transformers and switched tap autoformers.

10. MIT (Music Interface Technologies): 13620 Lincoln Way, Unit 320, Auburn, CA 95603-3261, 916 888-0394. Leading manufacturer of audiophile cables. Recently active in the power conditioning business.

11. Monster Cable Products, Inc.: 455 Valley Drive, Brisbane, CA 94005, 415 840 2000. World's leading manufacturer of audiophile cables. Recently introduced a line of surge protectors and line filters.

12. MSB Technology, Inc.: 14251 Pescadero Road 3/30 La Honda, CA 94020, 415 747 0271. MSB makes the only audiophile UPS. Primarily in the D/A converter business.

13. New Frontier Electronics: 2744 North Sugan Road, New Hope PA 18938 215 862 9344. Makes series mode surge suppressors.

14. Panamax: 150 Mitchell Boulevard, San Rafael, CA 94903-2057, 800 472 5555. Leading manufacturer of surge suppressors.

15. SanRex: 3000 Marcus Avenue, New Hyde Park, NY 11040-1008, 888 462 1028, 516 352 3800. Makes a wide range of UPSs.

16. Seakay: 8 Plant Drive, Waterford, CT 06385, 860 739 5899. Makes a "black box" solution that supposedly provides surge suppression and power factor correction. Distributes USES.

17. Servodrive Inc.: 1940 LeHigh Avenue, Unit C, Glenview, IL 60025, 847 724 5500.

Sola Hevi Duty: Box 268, Goldsboro, NC 27533-0268, 800 377 4384. Manufacturer of power conditioning products.

18. Tice Audio, 1530 Cypress Drive, Suite C, Jupiter, FL 33469, 407 575 7577. Manufacturer of isolation Transformers.

19. Toshiba International Corp.: 280 Utah Avenue, South San Francisco, CA 94080, 415 872 2722. Makes electrical generators and ultra-high spec UPSs.

20. Transtector Systems: 10701 Airport Drive, Hayden Lake, Idaho 83835, 800 882 9110, 208 772 8515. Manufacturer of avalanche diode surge suppressors.

21. Tripp Lite: 500 North Orleans, Dept TR, Chicago, IL 60610 312 755 5401. Best known for surge suppressors, but also makes UPSs.

Consultants

1. American Power Conversion: 132 Fairgrounds Road, West Kingston, RI 02892, 800 8004APC, 401 789 5735.

2. R.O. Associates: 10701 Airport Drive, Hayden Lake, Idaho 83835, 800 882 9110, 208 772 8515.

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Power Line Conditioners

by Chris Steinwand | Feb 01 '03

Contrary to what the electric companies would have you believe, all voltage is not created (or distributed) equally. One hundred twenty volts is more wishful thinking than reality most of the time. Yet most electronic equipment for use in North America is designed to operate at 120V, alternating 60 times per second. Go too far outside of that range and you encounter problems, especially with digital equipment, which must operate in a highly regulated environment.

If that weren't enough cause for concern (and problems with your install), there is also the possibility (probability?) that the electric lines you have access to for your install are probably being shared by other devices such as air conditioners/heaters, refrigerators, and any number of other devices that will create frequent fluctuations and surges in your AC power. Any of those devices can also introduce noise into the power lines. Power conditioners do help to filter out the unwanted noise, and even though the incoming power line is not the most common source of noise interference, the protection is still good to have and can save you many a headache.

Power surges, voltage spikes, and electromagnetic noise can all cause potential problems with electronic equipment. There are many products available to address each area of concern, but one product group addresses all three problems. These nifty black boxes are called power conditioners or line conditioners. The correct term is power line conditioner, but however you say it, in order to be considered a power conditioner in the generally accepted sense of the term, the unit must incorporate surge protection, electromagnetic-interference/radio-frequencyinterference (EMI/RFI) noise filtering, and voltage regulation. For most professional installations, it was felt that these devices should also be rackmountable. These were the key criteria used to define this technology spotlight.

VOLTAGE REGULATION

At the top of the list is the line-leveling function, or voltage regulation. The professional audio, video, and lighting equipment people use is usually

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designed to operate on 115V (or so) of AC power. Most equipment can tolerate a fairly broad variance of line voltage, but every product has its limits. When those limits are exceeded, damage can occur. The voltage regulation function of a power conditioner establishes high- and low-voltage limits that are usually within the safe operating range of the equipment it is protecting, though today's digital gear tends to have tighter tolerances.

If you're installing equipment in a building that shares its main power line with other buildings or high-current draw devices like air conditioners, microwave ovens, and coffee machines, the fluctuations in the voltage are likely to exceed the tolerance of your equipment at some point.

Ideally, the output of a power supply should be at a constant voltage. Unfortunately, this is difficult to achieve. Two factors can cause the output voltage to change. As previously mentioned, the AC line voltage is not constant. The 115V reference level is just that: a reference. AC power can actually vary from about 105 VAC to 125 VAC under normal conditions. The AC line voltage alone can be responsible for as much as a 20 percent change in the DC output voltage of a power supply. A change in the load resistance can also affect the DC output voltage. In complex electronic equipment, the load can change as circuits are switched in and out. In a video monitor, for example, the load on a particular power supply depends on the brightness of the screen, the control settings, and many other factors. Some voltage regulators have the ability to maintain a steady voltage by stepping up or stepping down the voltage. Stepping down is not a problem, but when you step voltage up, you do so by lowering the available current (or amperage). That is not always wise in a situation in which your equipment requires large amounts of current. For example, if you were running a conventional power amplifier at high volume and there was a sudden drop in the voltage right when the amp was required to produce a particularly loud or low frequency, your voltage regulator would raise the voltage, but the amp could no longer draw the current it needed to produce that note. That could cause a circuit breaker to trip, shutting down the whole rack of equipment.

Because most power supplies have a fixed internal resistance, they cannot absorb large fluctuations in AC voltage. As the load resistance decreases, the internal resistance of the power supply decreases the voltage across the load. Whereas that has the potential to damage any electronic equipment, digital devices are especially susceptible to fluctuations in DC voltage.

In general, circuits are designed to operate with a particular supply voltage. When the supply voltage changes, the operation of the circuit may be adversely affected. Consequently, some types of equipment must have power supplies that produce the same output voltage regardless of changes in the load resistance or changes in the AC line voltage. That is where the voltage regulation function of a power conditioner comes into play. By constantly monitoring the AC voltage level and limiting it when necessary, a more consistent voltage level is maintained, lessening the chances of damage to or erratic behavior of your equipment.

SURGE SUPPRESSION

The next and possibly most critical function of a power conditioner is surge protection. In addition to the constant variations on line voltage, there are many events and conditions that can cause surges, or spikes, in the AC power line that can damage transistors, make logic chips to

behave erratically, and even cause transformers to explode under extreme circumstances.

Voltage spikes and surges are the silent equipment killers. What makes these events particularly nasty is that you never know when they are going to occur, they happen so quickly that there is rarely any trace evidence (other than the damaged equipment), and a voltage spike may damage one component or all of them. It might occur several times before inflicting any damage, or it could cause total product failure the first time it occurs. Its ability to invade an electronic component and take out just one resistor or change the value of just one capacitor makes it more than just dangerous. It can leave you scratching your head as to exactly why your equipment is behaving abnormally. And head scratching in front of clients is generally frowned upon and to be avoided whenever possible.

(For a more in-depth explanation of surge protection, see "Shelter from the Storm" on p. 38.")

EMI/RFI FILTERING

EMI/RFI noise filtration isn't really a critical factor in preventing equipment failure, but it is an important step in helping to insure that the best sound and picture quality are delivered on a consistent basis.

EMI and RFI are terms that are often used interchangeably, though they are not the same thing. EMI is a specific type of noise that can be introduced into a power line, whereas RFI represents the frequency range (or pitch) of noise that can be introduced into a power line. They often go hand in hand, but not always. Both can cause noise problems, especially in installations in which power lines are run close to or touch audio/video signal cables. Power lines can also act as antennas for picking up noise and transmitting it directly into the electronic circuitry, where it can do anything from producing an audible buzz to causing equipment to malfunction.

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S&VC

Power Line Conditioners

by Chris Steinwand | Feb 01 '03

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Although there are many ways that EMI/RFI noise can be introduced into an audio or video signal path, the first line of defense is to eliminate any noise from the incoming power lines. It is ironic that the equipment you are trying to protect from unwanted noise is often the worst culprit in producing it.

In the case of power conditioners, filtering out the noise is usually accomplished with a series of passive resistors and capacitors applied to the power lines to create bandpass filters in much the same way that they are applied to a speaker system crossover to block high and low frequencies.

THE PRODUCTS

There are many manufacturers of high-quality products that accomplish one or two of the functions described in this article, but in the interest of minimizing confusion, the focus is limited to products that meet all three criteria in a rackmountable housing.

MANUFACTURERS

Applied Research and Technology (ART). ART recently unveiled its 400 Series Digital Power Distribution Systems, models 401, 402, and 403. All offer surge/spike protection, EMI/RFI filtering, frontmount circuit breaker, 1,800W capacity, and eight rear AC outlets. The 402 and 403 units add AC line-voltage metering and pull-out rack lights with dimmer; the top-end 403 includes a load current ammeter.

ETA Systems. ETA Systems offers a broad range of models, each with a slightly different feature set tailored to specific applications, but all are built on the same foundation. The ETA models have a convenient, easy-to-understand nomenclature structure. The PD in the products' names stands for power distribution. The numeric portion identifies how many AC outlets the unit contains. The L means the unit has pull-out rack lights. It's important to note that the lights used in the ETA boxes are 110V "Christmas tree" lights, which can be purchased virtually anywhere. They also do not have a variable dimmer — just a high/low switch. The reason for that is to minimize the possibility of introducing noise into the system. An improperly shielded dimmer or DC converter can create noise. The V signifies an LED volt meter that is accurate to within ¼ of a volt. One S

means it uses sequential step-up or -down transformers and surge protectors. The SS models also use the sequential technology and are standalone units that are not able to daisy-chain with other conditioners. The P identifies the pro series, which has the beefier 20-amp capacity.

Furman Sound. Furman also has a broad range of products that are divided into the 15-amp and 20-amp categories. Both lines feature a frontmounted circuit-breaker switch, but the 20-amp version is rated for use as a master switch, which is convenient for use in buildings where fire and safety codes aren't always followed to the letter and where you might find yourself tapped into a power line that's on a 50-amp breaker somewhere in a dungeon. To put this into perspective, 50 amps of current on a 115V line would equal approximately 6,000W of power, which translates into the potential to do a great deal of damage.

The Furman models use MOVs and gas-discharge tubes to control voltage spikes. This combination allows the larger units to absorb as much as 11,000 amps, which is not uncommon in the event of a lightening strike. All of the Furman units also have the high-voltage shutdown protection common to power conditioners. Front-panel LEDs show line voltage and protection status.

Panamax. Panamax makes several products focusing on surge protection and noise filtration. Its MAX 5500 and 5510 incorporate a dual-filtration system. Four of the unit's ten AC outlets deliver power through a large isolation transformer, providing ultraclean power for digital equipment, such as CD/DVD players and hard-drive video players. Another four outlets are filtered through balanced "double L" circuits to remove unwanted noise.

Two of the power outlets have a "delayed-on" feature to accommodate large current-draw equipment such as power amplifiers or powered subwoofers. Both units also provide surge protection for coaxial cables and a telephone line. Voltage regulation is accomplished through a high and low current limiting filter. If the incoming voltage exceeds or falls below the set parameters, a protection circuit kicks in to protect the gear. They use a combination of analog meters and LEDs for status display and come with a detachable convenience lamp that has a handy dimmer control.

SurgeX. SurgeX takes a distinct approach to surge protection (see the sidebar "The Nondiversionary Alternative"). Whereas most surge protectors shunt the surges to the ground path, SurgeX models actually store the excess electricity and then slowly discharge it across line and neutral, which avoids contamination of the equipment ground conductor. That is especially useful for protecting digital equipment, because logic chips are particularly sensitive to negative power spikes and unstable equipment ground.

SurgeX conditioners use three circuits for surge/spike protection: a series reactor current limiter, a dual-polarity voltage limiter, and dual pulse inverters. They also utilize an impedance tolerant noise filter. Future models may also incorporate a proprietary approach to voltage regulation.

Tripp-Lite. Tripp-Lite has one entry in the power conditioning product group, but it has some distinct features. It employs transformer-based voltage regulation to keep the voltage at a true 120V, even if the incoming voltage drops as low as 87V. Of course, that is accomplished at the

expense of amperage, but in applications in which steady voltage is more critical than high-capacity current draw (read: computers and telephone systems), this is a valuable feature. This unit is beefy, too. It delivers as much as 20 amps of current without breaking a sweat. Seven LEDs on the front panel register incoming voltage levels. The unit has a total of 14 AC outlets: 12 on the back and 2 up front.

SUMMARY

As more and more of the equipment people use is digitally based, the need for clean power will continue to increase. Regardless of the gear you specify into an install, some type of power protection is always a good idea. Power conditioners provide a nice combination of protection against so-called "dirty" power and noise in the building's power source.

Chris Steinwand is a marketing veteran of the pro audio/video industry, a freelance writer, and the director of Stonejam Consulting. You can reach him through e-mail at chris@stonejam.net.

The Nondiversionary Alternative

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Power Line Conditioners

by Chris Steinwand | Feb 01 '03

...continued from page 2

Nondiversionary surge suppressors act as lowpass filters, which simply block the high-freque wire. (The weight of the surge reactor is the reason these products weigh much more than otl current that passes to equipment connected to the unit passes through this filter. The remaini after it has been slowed by the surge reactor. It is then stored for the duration of the event an equipment ground. This type of surge suppressor can thus be placed anywhere along a powe ground is never contaminated and interconnected equipment is not put at risk when a surge c surge suppressors incorporate floating clamping voltage circuitry, which will withstand consid surge endurance specification of A-1-1, the highest possible rating available (the UL A-1-1 su highest surge voltages and currents likely to be encountered in a typical building), as specifie kind, effectively guaranteeing an unlimited service life without the requirement for testing or p

Comparing Power Line Conditioners

	Model	UL Listed	Operating Voltage	Total Amps	Total Wattage	Rack Spaces	No. Re Out
ART	401	x	120	15	1,800	1	8
ART	402	x	120	15	1,800	1	8
ART	403	x	120	15	1,800	1	8
ETA Systems	PD8	x	120	15	1,800	1	8
ETA Systems	PD8L	x	120	15	1,800	1	8
ETA Systems	PD9L		120	15	1,800	1	8
ETA Systems	PD10VRS		120	15	1,800	1	10
ETA Systems	PD11LP	x	120	20	2,400	1	10
ETA Systems	PD11LV	x	120	15	1,800	1	10

ETA Systems	PD11LVP	x	120	20	2,400	1	10
ETA Systems	PD11LVSP	x	120	20	2,400	1	10
ETA Systems	PD11P	x	120	20	2,400	1	10
ETA Systems	PD11SS	x	120	15	1,800	1	10
ETA Systems	PD11SP	x	120	20	2,400	1	8
ETA Systems	PD11SSP	x	120	20	2,400	1	10
ETA Systems	PD11VP	x	120	20	2,400	1	10
Furman Sound	PL-8	x	120	15	1,800	1	8
Furman Sound	PL-Plus	x	120	15	1,800	1	8
Furman Sound	PL-Pro	x	120	20	2,400	1	8
Furman Sound	PM-8	x	120	20	2,400	1	8
Furman Sound	PM-Pro	x	120	20	2,400	1	8
Furman Sound	PS-Pro	x	120	20	2,400	1	8
Panamax	5500	x	120	15	1,800	2	10
SurgeX	SX1115R	x	120	15	1,800	1	8
SurgeX	SX1120 RT	x	120	20	2,400	1	8
SurgeX	SX2120	x	120	20	2,400	2	14
SurgeX	SX2120 SEQ	x	120	20	2,400	2	12
Tripp-Lite	LCR2400		120	20	2,400	3	12

For More Information

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www.artproaudio.com

2 201

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www.etasys.com

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www.furmansound.com

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Energy Technologies, Inc.
Rugged Power ◇ Global Solutions

GLOSSARY P,Q,R

Up
GLOSSARY D,E,F
GLOSSARY G,H,I
GLOSSARY J,K,L
GLOSSARY M,N,O
GLOSSARY P,Q,R
GLOSSARY S,T,U
GLOSSARY V,W,X,Y,Z

P [A B C D E F G H I J K L M N O P Q R S T U V W X Y Z]

p - pico used to express 0.000000000001 (10 to the -12th power) times the standard unit, i.e. pF

Parallel Online UPS - Online UPS technology that provides redundant sources of conditioned backup power so that the critical load is protected even in the event of UPS component failure.

Peak Voltage - Also called peak-to-peak voltage, it is a measure of an AC waveform of the highest peak-to-peak voltage present on the waveform. A proper 120V AC waveform will have a peak voltage of about 170 volts. See RMS.

PDU - Power Distribution Unit. This electrical device is used to control the distribution of power to the individual loads. Control may be as simple as a series of switch or circuit breakers to interlocked logic operating solidstate relays. Available as a stand-alone unit or integrated into the UPS.

Power Factor (PF) - Power Factor, the cosine of the phase angle between the Watts (real power) used relative to the VA (apparent power), (Watts = VA x PF). Can be expressed as a percent or decimal number, i.e. a PF of 0.65 is the same as a PF of 65%.

Power Factor Correction (PFC) - An active or passive input circuit to change the power factor of the input current to a device so that it is closer to a PF of 1.0. Numerous benefits include reduced input line current and lower input harmonics.

Power Conditioner (Line Conditioner) - A unit that provides clean, well regulated power. Input and output voltages may also be converted as well.

Power Management Software - Provides monitoring and shutdown for UPS and

connected load.

Push-Pull - Converter topology usually configured as a forward converter, but uses two transistor switches and a center tapped transformer. The transistor switches turn on and off alternately. Also see Boost Regulator, Buck Regulator, Bridge Converter, Flyback Converter and Resonant Converter.

PWA (PCA) - Printed Wiring Assembly (Printed Circuit Assembly), refers to the individual assembled electronic cards used in an electronic product.

PWB (PCB) - Printed Wiring Board (Printed Circuit Board), refers to the bare circuit cards used in PWAs.

Q

[A B C D E F G H I J K L M N O P Q R S T U V W X Y Z]

Q (Q Factor) - A measure of the relative losses in an inductor. It is also known as the quality factor, defined as the ratio of inductive reactance to effective resistance. Q is zero at the SRF of an inductor.

R

[A B C D E F G H I J K L M N O P Q R S T U V W X Y Z]

Rack - A mechanical structure for mounting electrical equipment. Size and mounting patterns are defined by EIA 310.

Rack unit (U) - A common increment of equipment space height as defined by EIA 310. Typically 1 U equals 1.75 inches in height. Racks are sized in whole number of unit, i.e. 45 U rack has 78.75 inches of panel space.

Rackmount - A piece of electronic equipment such as a UPS that can be mounted in a rack along with servers, hubs, and other devices.

Receptacle - A contact device installed at an outlet designed to accept a single plug. Receptacles on the rear of a UPS accept plugs from supported system equipment such as computers or monitors.

Rectifier - An electronic device that converts AC power to DC power (AC/DC)

Redundancy - Duplication of elements in a system or installation to enhance the reliability or continuity of operation.

Regulation - A method of limiting voltage to a narrow range.

Redundant Operation - Parallel configuration of converters used in distributed power system to increase system reliability. Converters may be used in a N+1 architecture.

Remote Sensing - Using sense leads connected at the output load provides feedback to voltage regulation circuits of a converter. This arrangement is used to compensate for voltage losses from long leads to a load.

REPO - Remote Emergency Power Off. See Emergency Shutdown.

Resonant Converter - Switching converter technology in which a resonant tank circuit operating at very high frequencies is used to transfer energy to the output.

Reverse Voltage Protection - Converter feature that prevents damage to internal components if a reverse voltage is inadvertently applied to the input or output terminals.

RMS - Root Mean Square. The square root of the average value of the squares of all instantaneous values of voltage or current during one half cycle in an AC circuit. For a sine wave, the RMS value is approximately equal to 0.707 times the peak value of the waveform. RMS is also called the effective value.

Rolling Blackout - A condition where power utilities purposely impose blackouts over a portion of their service area to free up capacity so that the remaining service area can continue to be served. After a time, another portion of the service area has a blackout imposed on it, so that power can be restored in the original area.

Rolling Brownout - A condition where power utilities purposely impose brownouts over a portion of their service area to free up capacity so that the remaining service area can continue to be served. After a time, another portion of the service area has a brownout imposed on it, so that power can be restored in the original area.

RS-232 - Also called serial ports; a method of communicating digital information in which the data bits are transmitted sequentially over one line.

This page was last modified on: March 04, 2004

Home Up

E-MAIL SALES@ACPEAM.COM

Dear Audiophile:

The *Power Line Conditioner* is designed to eliminate audio noise on the AC power line. One of the major usage is to improve *Hi-Fi Audio sound image*. This Power Line Conditioner cover wide frequency range up to 30MHz to filter out the noise components, but not just audio noise to provide a clean Power source. Besides of providing filtering capability, the conditioner also provide strong isolation between equipments.

As all Audiophile aware that *odd harmonic frequency* create bad *Hi-Fi Audio sound image*. We noticed that odd harmonics create bad sound more than even harmonics. Of course, all audiophile notice the difference by their *ears*. You will find a table which shows the typical attenuation of our *Power Line Conditioner*.

Other application of this Power Line Conditioner are any equipments which are sensitive to power line noise from Audio to 30MHz.

Every Power Line Conditioner come with their Limited Life time Warranty.

You are welcome to try the *Power Line Conditioner & return to us with original packing for refund if you are not satisfied (applicable Tax & delivery charges are not refundable).* No question will be asked. Just pack & return at original condition for refund. As a serious Audiophile & a person who care about the effect of the power line noise, You will be amazed by the difference.

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home POWER LINE CONDITIONER WHERE TO FIND CONSULTATION CONTACT US

Line conditioner

Device used to protect the computer from variations in the power supply, such as spikes and brownouts. It is connected to the wall outlet, and the computer is then plugged into it.

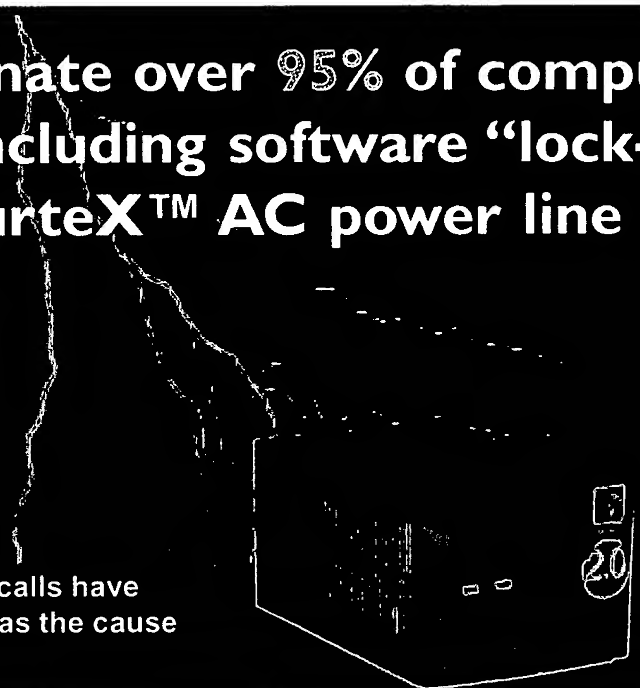
Also see: Line, Power definitions

SecurteX™ Digital

SLC

Protect the System That Protects Your Assets

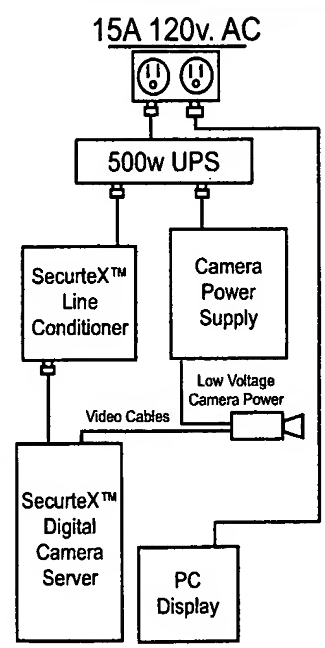
Eliminate over 95% of computer problems including software "lock-ups" with SecurteX™ AC power line Conditioners



80% Of our tech calls have identified power as the cause to DVR failure

SLC
SecurteX™ Line Conditioner

- Typical facilities experience over 6200 measurable power disturbances per year.
- Power disturbances can cause computer lock-ups, corrupted or loss data, and unexplained equipment and board failure. A line conditioner produces pure AC power with no harmful transcients or corruptions.
- Power surges reduce the life of computer boards. Delicate circuitry is not designed to withstand voltage surges. A surge suppressor clamps voltage in a safe range within micro seconds of a power spike that could destroy the unprotected circuit board in a computer.
- The average UPS (Uniterruptable Power Supplies) is not enough to protect your system and may actually add to the problem by generating "electric noise" of their own.



SecurteX™ Line Conditioners protect your system 3 ways.

- **Surge Diverter** -- Eliminates voltage spikes and impulses that can degrade or destroy computer components.
- **Isolation Transformer** -- Eliminates common voltage problems that will corrupt data, create communication errors and system lock-ups. Commany called electrical noise that is carried along on 120V AC circuits.
- **Noise Filter** -- Provides a low impedance path to the ground for electrical noise before it reaches the computer.

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The "Neutral Zone"

<back<

The *"Neutral Zone"*® Power Line Conditioner by *MultipointUSA (standard unit) The AC power that your home or office receives from the power company is extremely dirty and full of noise. It's fine for normal use but is unacceptable for powering electronic equipment. A typical AC power line is clogged with noise, distortions and other electronic pollution that leaks into your equipment, and degrades performance. Your power line picks up pollution from industrial equipment, street lights, transformers, anything that shares the line with your building brings in pollution. A very big source of outside pollution is from radio stations AM, FM, the copper lines in your home act like a giant antenna bringing in every signal around into your AC outlet. The most acceptable way to power your electronic equipment is through a Power Line Conditioner. It filters incoming AC power by trapping noise and dumping it back to the ground. It also filters out RF and EMI and other distortions. Protects equipment from line spikes (high voltage transients from power company switch gear) and from lighting strikes that cause catastrophic surges in power lines. Our Power Line Conditioner starts by being a shielding fixture first, the enclosure is made from four layers, mild steel, galvanized steel, brass, and then several layers copper shielding inside. Each layer is completely sealed so its not only a electrical seal but a magnetic seal as well, even the power cord has its own shield. The first stage is a 30A line filter with fast acting surge and spike protectors, this will dump most of the heavy duty pollution. The second stage is multiple each load is filtered in multiple stages so equipment can operate within its' own parameters and be pollution free. Each plug is ground faulted with it's own fast acting circuit breaker so one system's failure will not compromise other equipment connected to the same conditioner. The final stage is a industrial grade receptacle with large copper contacts. This might seem a little heavy duty but electricity does not fool around, the only way to deal with pollution is to totally seal it out. When it comes to protection the only path is to ground. Specifications: range 85-135VAC / load reg. .2% / ripple 1% / R.R.R. >92"db" / temp. stability 1% / therm. reg. .002%/W / line reg. .01% / ref. voltage 1.25V / output tolerance 1% / 15Amp overall load.*

Also available in 1 U rack mount for single set up, with all the same characteristics six receptacles four stage conditioning at ten (10) amps. will feed signal type units and power amps. weighting a mere *6 lbs. !*

Price: $ 499.00

Also available in reference standard, transformer isolated power feeds

The "Neutral Zone Stage"

Power Line Conditioner

If you have played live, you know the biggest problem you have besides the club owner is your power feed. If you can find more than one receptacle it's usually full of characteristics you don't want coming out of your equipment, Noise! Imagine a power feed that is totally neutral, your entire band can plug into one point. In a clean balanced atmosphere you will hear your equipment sound the way it was meant to be. Greater Dynamic Range, Increased Bass Response, Larger Sound Stage, and one thing worth its weight in gold, CLEAN TIGHT RESPONSE!

Available in a rack mounted unit the "Neutral Zone Stage"® POWER LINE CONDITIONER A Heavy Duty Line Conditioner that has three stage input filtering for noisy environments and four stage filtering for each output, with separate output for pre-amp type equipment and power amps. The 20Amp unit comes with five double GROUND FAULT receptacles each with its own fast acting circuit breaker, so if one unit goes down the others are unaffected. The unit also comes with two extension cords, one ten ft. and one twenty ft. shielded #10/3 30Amp stranded industrial duty silicone covered Twist Lock cords. Plus balanced output isolation and input isolation transformers if required. (added cost) They operate on a 120Volt line or 240Volt feed, in 20A / 30A / 40A / 50A / feeds. These units are made for continuous LOAD with efficiency rating of almost 100%. A balanced load will make the most of what you have to work with electricity wise, that comes out of your typical electrical outlet in a club setting. The ideal set up for Live performances. At the following specifications: transformers Toroidal / continuous duty at full load / 500% head room @ full spike / surge@ 10,000amps. / four stage input filters E.M.I. etc. / two stage output filters / load reg. .02% / ripple 1% / R.R.R. 93"db" / temp. stability 1% / therm. reg. .002%/w / line reg. .01% / ref. voltage 1.25V / output tolerance 1% / five industrial grade 20A no-fault receptacles / input 30A twist lock / main circuit breaker / pilot light neon / power switch industrial grade 20A / all wiring #10 pure copper 256 strands-polypropylene / all filters #10 / all caps. 1% polypropylene / Case: 18 ga. / rack mount / triple shield / weight 20A-35lbs. Power Cords: silicone outer covering / good abrasion and radiation resistance, heat endurance, high dielectric protection (11,000volts). Meets requirements MIL-I-3190/6, complies with U.S.L. UW-1 Flame test File#3690 Class 200 continuous use at +200°C to -73°C, UL File#E-63450 200°C 600volts, CSA File#LR 58486-HFS, lubrication layer-fiberglass covering with oil based silicone / inner covering rubber / three conductor with shield 130:db" noise reduction / conductor #10-256 strands-polypropylene / two cords supplied one 10 ft. and one 20 ft. Starting Price.....$ 1,500.00

The "Neutral Zone Reference"

Transformer Isolated Power Reference

The ultimate in power line filtering a transformer isolated balanced power feed. The unit is hard wired to the service panel, must be installed by a professional. A toroidal transformer isolates the power through induction, there is no physical connection to the power feed. Even the transformer coils are wound separately and then assembled. The physical unit is triple shielded, each layer is totally sealed from the next. (copper / mild steel / copper / galvanized mild steel) Maintaining an absolute pure power signal. The unit has all the features of a totally isolated Neutral Zone on an industrial scale. The unit can also be equipped with an ups power source at added cost. All units are hand made to customers specifications per order. Starting Price .....15 Amp. $ 2,500.00

Neutral Zone Power Chain

(Standard 15A basic unit)

Shielded #14 to #10 Industrial Grade Stranded Power Cord

16 Gauge Steel Enclosure with Sealed Three Layered Continuous Metal Shield

All Receptacles and Filters are Shielded

30 Amp Line Filter with Surge and Spike Protection

15 Amp Fast Acting Circuit Breaker

20 Amp Industrial Grade Power Switch

FOUR STAGE Master Line Filter

Balanced Power Layout

Four Stage Filtering for each receptacle

Industrial Grade Continuous Duty Ground Fault Receptacle with fast acting circuit breaker

Neutral running power feeding equipment

Equipment with extended Dynamics

Punch and power of a Pure Power Source